

# BIJU PATNAIK UNIVERSITY OF TECHNOLOGY, ORISSA

## M.TECH IN PLASTICS ENGINEERING

FROM THE ACADEMIC SESSION: 2009-2010

<b>FIRST SEMESTER</b>			
<b>Nature/ Parameter</b>	<b>No. of Subjects</b>	<b>Credits</b>	<b>Remarks</b>
Professional core	3	12	4 Credit each
Elective	2	6	3 Credit each
Sessionals /Laboratory	1 or 2	4	
Pre-Thesis work and Seminar	---	2	
<b>TOTAL</b>		<b>24</b>	
<b>SECOND SEMESTER</b>			
Professional core	2	8	4 Credit each
Elective	3	9	3 Credit each
Sessionals /Laboratory	1 or 2	4	
Pre-Thesis work and Seminar	--	2	
Comprehensive Viva Voce-I	---	2	
<b>TOTAL</b>		<b>25</b>	
<b>THIRD SEMESTER</b>			
Thesis part-I	----	14	
Open Elective	----	3	
<b>TOTAL</b>		<b>17</b>	
<b>FOURTH SEMESTER</b>			
Thesis part-II	---	20	
Seminar	---	2	
Comprehensive Viva Voce-II	---	2	
<b>TOTAL</b>		<b>24</b>	
<b>GRANT TOTAL</b>		<b>90</b>	

**Total credits: 90 (Break-up as per BPUT guidelines)**

<b>Subject Items</b>	<b>Credits</b>
Professional Core	20
Professional Elective	18
Sessionals / Laboratory	8
Thesis / Project	34
Seminar	6
Comprehensive Viva-Voce	4
<b>TOTAL</b>	<b>90</b>

## M.TECH IN PLASTICS ENGINEERING

### FIRST SEMESTER

Code	Course Title	L	T	P	Credit
<b>1. Professional Core</b>					
PLPC101	Polymeric Materials	3	1	0	4
PLPC102	Additives and Compounding	3	1	0	4
PLPC103	Plastics Processing Technology	3	1	0	4
<b>Elective-I (Any One)</b>					
PLPE101	A) Composites Materials	3	1	0	3
PLPE102	B) Plastic Foams				
PLPE103	C) Numerical methods in Plastics Processing				
PLPE104	D) Plastics Packaging.				
<b>Elective-II (Any One)</b>					
PLPE105	A) Mathematics for plastics engineers	3	1	0	3
PLPE106	B) Fundamentals of Plastic Mould & Die Designing				
PLPE107	C) Safety and Pollution Control in Plastic & Polymer Industries.				
PLPE108	D) Fibre Technology				
<b>TOTAL</b>		<b>15</b>	<b>5</b>	<b>--</b>	<b>18</b>
<b>3. Sessional / Laboratory</b>					
PLPR101	Plastics Processing and Testing Laboratory	0	0	3	2
PLPR102	Plastics Product Design and Tooling, Software Lab-I	0	0	3	2
<b>TOTAL</b>		<b>0</b>	<b>0</b>	<b>6</b>	<b>4</b>
PLPT101	<b>4. Pre-Thesis work and Seminar - I</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>
<b>NET TOTAL</b>		<b>15</b>	<b>5</b>	<b>10</b>	<b>24</b>

### SECOND SEMESTER

Code	Course Title	L	T	P	Credit
<b>1. Professional Core</b>					
PLPC201	Properties & Testing of Plastics	3	1	0	4
PLPC202	Plastics Processing Theory and Product Design.	3	1	0	4
1	<b>Elective-III (Any One)</b>	3	1	0	3
2	<b>Elective-IV (Any One)</b>	3	1	0	3
3	<b>Elective-V (Any One)</b>	3	1	0	3
<b>TOTAL</b>		<b>15</b>	<b>5</b>	<b>--</b>	<b>17</b>
<b>3. Sessional / Laboratory</b>					
PLPR201	Plastics Product Design and Tooling, Software Lab-II	0	0	3	2
PLPR202	Plastics Processing and Testing Laboratory -II	0	0	3	2
<b>TOTAL</b>		<b>0</b>	<b>0</b>	<b>6</b>	<b>4</b>
PLPT201	<b>4. Pre-Thesis work and Seminar - II</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>
PLCV201	<b>5. Comprehensive Viva Voce</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>
<b>NET TOTAL</b>		<b>15</b>	<b>5</b>	<b>14</b>	<b>25</b>

### THIRD SEMESTER

Course Code	Course Title	L	T	P	Credit
1	Thesis part-I	---	---	---	14
2	Open Elective	3	1	0	3
<b>TOTAL</b>					<b>17</b>

### FOURTH SEMESTER

Course Code	Course Title	L	T	P	Credit
PLPT401	Thesis part-II	---	---	---	20
PLCV401	Seminar	---	---	4	2
PLCV402	Comprehensive Viva Voce-II	---	---	---	2
<b>TOTAL</b>					<b>24</b>

**TOTAL CREDIT (24+25+17+24) = 90**

**ELECTIVE SUBJECTS (3-1-0) 3 Cr.**

**ELECTIVE -III**

PLPE201	Polymer Blends and Alloys
PLPE202	Coating Science & Technology
PLPE203	Bio-medical Plastics
PLPE204	Biodegradable Plastics

**ELECTIVE -IV**

PLPE205	CAD/CAM/CAE application in mould/tool design
PLPE206	Polymer degradation and stabilisation .
PLPE207	Plastics waste management and recycling.
PLPE208	Mechanical behaviour of polymers

**ELECTIVE -V**

PLPE209	Production management
PLPE210	Nylon technology
PLPE211	Speciality elastomers
PLPE212	Strength of materials

**OPEN ELECTIVE (3-1-0) 3 Cr.**

PLOE201	Quality Management
PLOE202	Engineering Economic and costing
PLOE203	Human Resource Management
PLOE204	Marketing Management

# **POLYMERIC MATERIALS (3-1-0) 4 Cr.**

1. Introduction to Polymeric Materials, Techniques of Polymerization, Molecular weight and its distribution, Molecular Architecture (Linear, Branched, Cross-linked ) / Tacticity, Amorphous and Crystalline Polymers, Glass and Melting Transitions., Liquid Crystalline Polymers, Conducting polymers.
2. Sources and manufacturer of raw materials for polymers [C<sub>1</sub> – C<sub>6</sub>].
3. Comparative properties and applications :  
Thermoplastics : Polyolefin's (polyethylene's, polypropylene, vinyl polymers and copolymers, styrene-homo and copolymers, Acrylic homo and co-polymers, cellulose, nylons, aromatic polyamides and polyimides, PET, PBT and aromatic polyesters, fluoro polymers, polycarbonates, polyacetals, aromatic polyether/ polysulfones / polyphenylene / polyetheretherketone / polyurethanes / Thermoplastics / Thermosets).
4. Comparative properties and applications  
Thermosetting plastics : Formaldehyde resins (PF/UF/MF), Epoxy resins, unsaturated polyesters, silicones.

## **TEXT BOOKS :**

1. J.A.Brydson, "Plastics Materials", Butterworth Heinemann, Oxford, 7<sup>th</sup> edition (1999).
2. Fred W.Billmeyer, Jr., "Text Book of Polymer Science", John Wiley and Sons, Singapore
3. P.Ghosh, "Polymer Science and Technology of Plastics and Rubbers – New Edition.

# **ADDITIVES AND COMPOUNDING (3-1-0) 4 Cr**

1. Introduction to additives- Technological requirements, classification of additives, chemistry, function and mechanism, principles of mixing.
2. Fillers : Coupling agents, plasticizers and softeners, lubricants, flow promoters.
3. Antiageing additives : Antioxidants, antiozonants, stabilizers (UV/Thermal etc), UV absorbers, Flame retardants, coloring materials, blowing agents, cross-linking agents, toughening agents.
4. Mixing and compounding techniques : EQUIPMENTS : Batch mixers and continuous mixers, two / three roll mills, Intermix, ribbon blender, planetary mixer, single screw and multiple screw mixer, extruders.  
Principles and operating details of the above mentioned equipments.

## **Text Books :**

1. R.Gachter and H. Muller, "Plastics Additives Hand Books", Hanser Publications, Munich (1993).
2. J.A. Brydson, "Plastics Materials" Buterworth – Heinmann, Oxford (1999).
3. J.Murphy, "The additives for Plastics Hand Book", Elsevier, Oxdford (1996).

# **PLASTICS PROCESSING TECHNOLOGY (3-1-0) 4 Cr**

1. Extrusion : Introduction and Principles – Single screw, specifications, types of screw (single/twin, extruder parts and their functions); products defects, causes and remedies. Extrusion blow molding and stretch blow molding-process sequences, the machine, multiple cavity blow molding, co-extrusion, preform production, comparison between blow and stretch blow molding.
2. Injection : Introduction and principles, components-functions, process variables, product defects and remedies. Injection blow moulding, Thermoplastics and thermosetting comparative behaviors.
3. Compression and transfer moldings : Introduction and principles, machine process and process variable, product defects and remedies, comparison between the above – mentioned process.
4. Rotational molding and thermoforming process : Principle and practices.

## **TEXT BOOKS :**

1. D.H.Maron-Jones, “Polymer Processing”, Chapman and Hall, London(1989) or newer edition.
2. W.Michaeli, “Plastics Processing – An Introduction” Hanser Publishers, New York (1992).
3. Seymour S.Schwartz and Sidney H.Goodman, ‘Plastics Materials and Process, Van Nostrand Reinhold Co., New York (1982).

## **ELECTIVE – I (Any one)**

### **COMPOSITE MATERIALS (3-1-0)**

1. Composite materials for structural applications, Manufacturing methods of FRP composites, polymers and ceramics.
2. Fibrous and particulate composites, Micromechanical and Macromechanical behavior of orthotropic laminate and laminated composites.
3. Evaluation of strength and failure criteria of composites, Optimum fiber reinforcement criteria, Kelly-Davies model.
4. Testing, joining, environmental effects and the effects of defects on performance of composites, interpenetrating network.

## **TEXT BOOKS :**

1. Lawrence E.Nielsen and Robert F. Landel, “Mechanical Properties of Polymers and Composites”, 2<sup>nd</sup> Edition, Marcel Dekker, New York (1994).
2. B.T.Astrom, “Manufacturing of Polymer Composites”, Chapman and Hall, London (1995).
3. T.G.Gutowski, “Advanced Composites Manufacturing:”, John Wiley and Sons, New York (1997).
4. Jones, R.M. “Mechanics of Composites Materials” Scripta Book Co.

## **PLASTICS FOAMS : (3-1-0)**

1. Introduction to foams, type of foams (open and closed cell) and its applications, Manufacturing process, formulation and compounding of foams.
2. Rigid and flexible foams – stiffness and strength.
3. Characterization, testing and properties of foams with special reference to fatigue, shock absorption, acoustical behavior morphology etc.
4. Reinforcement of foams : Low and High-density foams and the reinforcing materials and methods.

### **TEXT BOOKS :**

1. N.C.Hilyard, "Mechanics of Cellular Plastics", Applied Science Publishers, London (1982).
2. John Brydson, "Plastics Materials", 7<sup>th</sup> edition, Butterworth – Heinman, London (1999).

## **NUMERICAL METHODS IN PLASTICS PROCESSING (3-1-0)**

Use of numerical methods in the solutions of problems concerning rheology, heat transfer, diffusion and viscoelastic theory.

### **Topics to include :**

1. (a) Ordinary differential equation  
(b) Simultaneous linear equations
2. (a) Finite difference methods  
(b) Interactive solution methods.
3. (a) Regression analysis  
(b) Interactive solution methods.
4. (a) Linear and quadratic interpolations  
(b) Curve fitting Techniques.

### **TEXT BOOKS**

1. Kreyszig : Advance Engineering Mathematics
2. Salvadori and Mc Carmik : Numerical Methods
3. C.S.Desai and J.F.Abel : Introduction to finite element method.

## **PLASTICS PACKAGING (3-1-0)**

1. Introduction and basis principles, Rigid and flexible packaging for food, beverages, cosmetics, pharmaceuticals, health care products electronics materials, Chemicals, equipments and machinery.
2. Flexible packaging : Manufacturing process, product evaluation, testing and applications.
3. Films for packaging materials and process, Bubble films, shrink films, plastics paper, multilayer films and laminates, cross linked films.
4. Sterilization of plastics – Dry heating, Radiation sterilization Chemicals sterilization, Supercritical carbon dioxide.

### **TEXT BOOKS**

1. A.S.Athalye, "Plastics in Packaging", Tata McGraw – Hill Publishing Co. Ltd., New Delhi (1992).
2. A.S.Athalye, "Plastics in Flexible Packaging", Multi Tech Publishing Co. Bombay (1992).

## **ELECTIVE – II (Any one)**

### **MATHEMATICS FOR PLASTICS ENGINEERS (3-1-0)**

1. Partial differential equations : Linear and quasilinear first order partial differential equations, second order linear equations in two variables and their classifications, Cauchy, Dirichlet and Newman problems, Green functions; Solutions of Laplace, wave and diffusion equations in two variable and application to physical problems.
2. Vector and tensor analysis, Matrices and Determinants, Vector differential calculus, Laplace and Fourier transforms. Introduction to numeric use of the above techniques in plastics engineering and calculations.
3. Probability : Random experiment, event space, classical and statistical definition of probability, conditional probability, probability distribution (both one and two dimensions). Distribution Functions : Binomial, Normal Poisson, Uniform, Cauchy and Gamma, Mathematical Expectation, Mean, Variance, Moment dispersion, Kurtosis, Median, Mode, Least square method of curve fitting, Regression Analysis, correlation co-efficient.
4. Statistics : Sampling theory, populations, sampling errors and bias, sampling methods : random, sampling distribution. Estimation and testing of hypothesis – theory of estimation, point estimates, consistent and unbiased estimates. Methods of point estimation – method of maximum likelihood, interval estimation, Null hypothesis, critical region.

### **TEXT BOOKS**

1. Kreyszig, "Advanced Engineering Mathematics".

# FUNDAMENTALS OF PLASTICS MOULD / DIE DESIGN (3-1-0)

## **Unit 1        Mould Design**

Orthographic projection-Projection of solids—vertical and horizontal surfaces-Inclined Surfaces-Curved Surfaces-Sectional views and assembly drawing.

## **Unit 2        Product Design**

Basic Principles-Shrinkage-Flash lines-Undercuts-suggested Wall thickness-Draft-Tolerance-Moulded holes-threads-radius- moulded hinges-integral hinge-snap fits - product design thumb rules - case studies and product design.

## **Unit 3**

Parting line-Construction of core and cavity-types of gate-types of ejection-Mould temperature control - cooling - Mould alignment Mould ancillary parts.

## **Unit 4**

Types of moulds-two plate - three plate - split moulds - Machine selection-Principles of shrinkage allowances-materials for mould parts-life of mould-mould maintenance-case studies on mould design.

## **Unit 5        Screw Design**

Extrusion -- extruder parts - extrusion screw - design features - design variables.

Injection Moulds for threaded components – automatic unscrewing – various unscrewing methods

Total Lectures = 45            Tutorial = 15

## **Text Books**

1. Injection Mould Design for Thermoplastic - By Pye, R.G.W
2. Injection Mould & Molding - By Dym
3. Injection Moulds – 130 Proven Design - By Gastrow, H
4. Plastics Product Design Engineering Hand Book - By Dubois, H
5. Plastics Product Design & Process Engineering - By Belofsky, Harold

## **Reference Books**

1. Plastic Design & Processing - By Sharma, S.C
  2. Plastics Moulds & Dies - By Sors, & Others
  3. Injection Mould Design Fundamentals (Vol. I& II) - By Glanvill & Denton
- Injection Mould -By VDI

# SAFETY & POLLUTION CONTROL IN PLASTICS AND POLYMER INDUSTRIES (3-1-0)

- Unit – I : Safety and Health at work, Managing safety, Safety Policy, Identification & evaluation of risks. Safety inspection – Checklist, documentation, Managers participation in safety, MIS.
- Unit – II : Environmental Engineering, Noise in Industry & its effect on Human being, effective methods of noise reduction, lighting for working, Heat stress in Plastics Industries & effects of over exposure to heat, combating heat stress industry. Industrial ventilations & Exhaust systems.
- Unit – III : Chemical Safety Management if Hazardous / toxic materials occupational health management, the human side of safety employees participation in safety accident prevention programme.
- Unit – IV : Earth & its environment, business enterprise, environmental issues related to the Plastics Industries – Global concern V/s Local & regional concerns, Global warming, depletion of stratospheric ozone. Polymer & Energy, Plastics in the Marine Environment. Environmental effects on polymeric materials.

## Text Books

1. Safety Management in Industry : N.V.Krishnan, Jaico Publishing House, 1997.
2. Plastics and the Environment Anthony L. Andraday, John Willy & Sons 2003.
3. Mc Grawhills Hazardss Chemicals safety guide for the plastics industry.
4. Plastics for Environment & Sustainable Development ICPE & CIPET Publication 2003 Ed.

## FIBRE TECHNOLOGY (3-1-0)

### UNIT-1

Introduction to natural and synthetic polymers. Essential characteristics and molecular architecture of fibre forming polymers.

### UNIT-2

Concept of order in polymers, crystallinity, orientation, physical structure of natural and man-made fibers.

### UNIT-3

Physical methods for investigating fiber structure. Optical properties of oriented polymers and fibres, refractive index and birefringence.

### UNIT-4

Melt spinning, dry and wet spinning of fibers. Fiber drawing, heat setting, texturing and mechanical properties of fibers based on viscose, cellulose acetate, polyamides.

### UNIT-5

Fiber drawing, heat setting, texturing and mechanical properties of fibers based on polyesters, acrylics, polypropylene, glass and carbon-fibres. General principles of finishing and dyeing of fibers. Common types of finishes applied to textile fibers.

## Reference Books

1. Billmeyer Jr.; Fred W., Synthetic Polymers, Doubleday and Co. Inc., New York (1972).
2. Gupta, V.B., and Kothari, V.K., Manufactured Fibre Technology, Chapman & Hall, 1997.
3. Fourne, Franz, "Synthetic Fibres, Machines and Equipment, Manufacture, Properties", Hanser Publishes, 1999.
4. Corbman, Bernard P, "Textiles fibre to fabric", Sixth Edition, McGraw Hill, 1983

# SESSIONAL / LABORATORY

## **PLASTIC PROCESSING AND TESTING LAB-I (0-0-3)**

1. Plastic Processing Lab (25 Hrs)
  1. Injection Moulding (Hand Operated)
  2. Injection Moulding (Semi-Automatic)
  3. Injection Moulding (Automatic)
  4. Extrusion Process
  5. Compression Moulding (Hand Operated)
  6. Compression Moulding (Semi Automatic)
  7. Blow Moulding (Hand Operated)
  8. Scrap Grinding.

### **2. PLASTICS TESTING LAB (20 Hrs)**

1. Chemical Lab : Identification of Plastics – Viscosity and Molecular Weight Determination – Determination of K.Value for PVC.
2. Demonstration : Melting point – Carbon black content – Filler content –Environmental stress cracking resistance – PH meter – Hopper viscometer – Brookfield Viscometer.
3. Specimen preparation Lab : Specimen preparation using injection moulding machine – compression moulding machine – two roll mill and contour cutter.
4. Demonstration : Scrap grinder – Blender.
5. Physico-Mechanical Lab : Tensile strength – Flexural strength – compression strength – Tear strength – Impact strength – Hardness.
6. Demonstration : Abrasion resistant tester – Folding endurance tester – Burst strength tester – Density gradient column – Creep tester – Moisture vapour transmission rate – gas permeability – Sieve analysis.

## **PLASTICS PRODUCT DESIGN AND TOOLING SOFTWARE LAB-I**

### **Part – I (0-03) 2 Cr.**

1. Basic Engineering Software.
2. Part drawing from product.
3. Design of mould elements.
4. Two plate mould design (Injection) single impression.

### **PRE-THESIS WORK AND SEMINAR (2 Cr.)**

# PROPERTIES AND TESTING OF PLASTICS (3-1-0)

### **UNIT – 1 : Concepts of Testing & Identification Of Plastics**

Basic concepts of testing-Specification and Standards – National and International Standards – Test specimen preparation – Pre-conditioning and test atmosphere.

Identification of plastics by simple test : Visual examination – Density – Melting point – Solubility test – Flame test – Chemical tests.

### **UNIT – II : Physical Testing**

#### **Long –term Mechanical Properties : Creep – Stress relaxation.**

Short-term Mechanical Properties : Tensile properties – Flexural properties – Compressive properties – Shear properties – Impact properties – Tear resistance – Hardness tests – abrasion resistance – Friction test.

Gas and Moisture Permeability – Environmental stress cracking resistance – Crazeing.

Dielectric Strength – Dielectric Constant and dissipation factor – insulation resistance – volume and surface resistivity – Arc resistance – Antistatic tests.

Refractive index – Luminous transmittance – Clarity and Haze – Photo –elastic properties – colour measurements and Specular Gloss.

### **UNIT – III : Thermal Properties**

Melt flow index : Heat deflection temperature – Vicat softening temperature – Marten's Heat resistance test – Brittleness temperature – Specific Heat – Glass transition temperature – thermal conductivity – Co-efficient of thermal expansion – Shrinkage – Thermal stability – Flammability.

### **UNIT – IV : Permanence Properties and Product Testing**

Water absorption : Chemical Resistance – UV resistance – Ozone resistance – weathering resistance – salt spray and straining resistance – Irradiation effects – Microbiological attack.

Testing of pipes and fittings – films and sheets – container – Foam – Laminates and FRP based products – Failure Analysis.

### **Text Book**

1. Vishu Shah, Hand Book of Plastics Testing Technology, John Wiley & Sons Inc. New York
2. R.P.Brown, Hand Book of Plastics Test Methods, George Godwin Ltd., London, 1981.
3. Analysis & Testing by Crompton.
4. J.S.Anand, K.Ramamurthy, K.Palanivelu how to identify Plastics by Simple Methods.
5. G.C.Lves, J.A.Mead, M.M.Riley, Hand Book of Plastics Test Methods, The Plastics Institute,
6. Frank T.Traceski, Specifications & Standards for Plastics & Composites, ASM International, Metals Park, OH, 1990.
7. J.Hasiam, H.A. Willis, Identification & Analysis of Plastics, London Iliffe Books Ltd., New Jersey,

# PLASTICS PROCESSING THEORY AND PRODUCT DESIGN (3-1-0)

1. Injection Moulding : Introduction to microprocessor control systems, effect of processing parameters on moulding quality, frozen in stresses, Annealing, Processing of Engineering Plastics, Statistically process control.
2. Fabrication & decoration of plastics – Sealing, Welding, Joining, Printing, Painting, Host Stamping, Vacuum metalizing, In mould decoration.
3. Calendaring : Introduction, type of calendars, roll, configuration, definition of terms such as calendar bank, calendaring process, process variable and application.
4. Concepts : Size, shape and function – form and function – Aesthetics, Ergonomics – Shrinkage, Flash lines, Undercuts – External & Internal – wall thickness – variance in wall thickness – suggested wall thickness for thermoplastics and thermosetting materials – steps in product design – emphasize on designing with engineering plastics – Taper or draft – Fits & Tolerance – Designing with plastics for load bearing applications like gear, bearing etc. Design of radii, fillets, ribs & bosses – Design for flow and shape – moulded holes – through hole – blind holes – threaded holes – side holes – holes parallel to draw – nearness of holes of each other and side wall – moulding holes not parallel to draw – drilled and tapped holes – moulded threads – moulded lettering – surface treatment.

## **Text Books**

1. Donald V. Rossato, Injection Moulding Handbook, International Thomson Publishing Co., 1995.
2. M.S.Welling, Injection Moulding Technology, VDI – Verlag GmbH, 1981.
3. Seymour S.Sctiwartz & Sidney H.Goodman, Plastics Materials and process, Van Nostrand Reinhold Company, New York, 1982.
4. RGW PYE Injection Mould Design for Thermoplastics, affiliated East-West Press P. Ltd., New Delhi 1989.
5. Beck, Plastics product design, Yan Nostrand Reinhold Company London.
6. Donatas satas Plastics Finishing and Decoration Van Nostrand Reinhold Company, New York. 1986.
7. James M. Margoills, decorating Plastics, Hanset Publishers, New York, 1986.

## Elective – III (Any one)

### POLYMER BLENDS AND ALLOYS (3-1-0)

1. Definition, classification and importance of polymer blends and alloys, copolymer vs. polyblends and alloys; concept of polymer miscibility, thermodynamics of polyblends.
2. Interchain forces in polyblends, interpenetrating polymer network in polyblends, morphology and phase separation.
3. Preparation, processing and properties, characterization techniques rheology of polyblends and alloys.
4. Applications of polyblends and alloys in adhesive, molded products, footwear, films, fibers, surface coating, miscellaneous uses, current trends in polyblends and alloys technology.

#### Text Books :

1. Polymer Blends & Alloys – An Overview,; RP Singh, CK Das, S.K.Mustafi, Asian Books Published 1<sup>st</sup> ed. 2002.
2. Polymer Blends & Alloys: Folkes & Hopes Blackie academic Professional 1993.
3. Advance in Polymer Blends & Alloys Technology by Malvyn Kohudic, Technomic, 1988.
4. L.A. Utracki, Commercial Polymer Blends, Chapman & Hall, London, 1998.
5. D.R.Paul & Seymour Newman, Polymer Blends, Vo. 1 & 2, Academic Press, New York, 1978.
6. Chris Rauwendaal, Polymer Mixing a self study guide, Hanser Publishers, Munich, 1998.

### COATINGS SCIENCE & TECHNOLOGY (3-1-0)

1. Basic paint technology ; Polymer binders, Pigments and extenders, additives.
2. Essential concepts of paint formulation and paint properties : pain preparation (pigment dispersion), surface preparation and paint application, paint properties and their evaluation, mechanism of film formation, factors affecting coating properties, methods used for film preparation and their properties; barrier properties and corrosion, mechanical properties, aging properties, rheological properties, adhesion properties and other related properties.
3. Mathematics of paint formulation, formulations of coating as finishes (automotive, appliance, coil, can, marine, aircraft etc.)
4. State of the art technologies, specialty coating (radiation durable, nonpolluting, powder, high solids etc.)

#### TEXT BOOKS

1. Outline of paint technology, W.M. Morgans (3<sup>rd</sup> Edition – Recently CBS Publishers.
2. Paints, Coatings and Solvents, Dieter Stage (ED.) – 2<sup>nd</sup> Edition – Wernon Freitag Ltd., (Eds).
3. Principle & Paint Formulation, R. Woodbroidge (Ed.) – 1991.

## **BIO-MEDICAL PLASTICS (3-1-0)**

1. Synthetic and Natural biomaterials used in Biomedical applications
  - i) Polyolefin's, Polyamides, Acrylic Polymers, Fluorocarbons, Polyesters, Engg. Plastics.
  - ii) Collagen, Polysaccharides, Proteins etc.
2. Human applications of Plastics : Cardiovascular implants, Dental Implants, Role of plastics in Ophthalmology, Hydro gels, Drug Delivery Systems, Sutures, Burn Dressings and Artificial Skin. Hernia Mesh, adhesives and Sealants, Artificial organs and devices, Blood bags, Condoms etc.
3. Blood – polymer interactions and blood compatibility, Chemical and biochemical degradation of polymers, Tissue engineering and polymers.
4. Testing and evaluation: in-vitro-/vivo; Standards in product development and regulations; Ethical and sociological issues.

### **Books**

1. Buddy D. Ratner, Allan S. Hoffman, Fredrick J.Schoen and Jack E. Lemons (eds), "Biomaterials Science – An Introduction to Materials in Medicine", Academic Press, San Diego (1996).
2. Joon B. Park and Roderic S. Lakes, "Biomaterials : An Introduction". 2 edition, Plenum Press, New York (1992).
3. Sujata V. Bhat, "Biomaterials", Narosa Publishing House, New Delhi, (2002).

## **BIODEGRADABLE PLASTICS (3-1-0)**

1. Plastics & Environment, Degradation, Bio-degradation of Plastics.
2. Renewable resources, synthetic & natural plastics, Biodegradable starch based polymers, Microbial Polyamino acid, Lignum, Aliginate based cellulose / PLA / PHA Polyester, Polysaccharides, Chitens & chitosan etc.
3. Emerging applications areas: Coated Papers, Agricultural Mulch Film, Shopping Bags, Food Waste Film and Bags, Consumer Packing Materials, Landfill Cover Film, Other applications.
4. Disposal Environments & Plastics Sorting and Reprocessing  
Composing facilities and soil Burial, Anaerobic Digestion, Waste Water Treatment Plant, Reprocessing Facilities, Landfills, Marine and Freshwater Environments, Litter, Key Issues, Recyclable Plastics Sorting considerations, Reprocessing Considerations.

### **Text Books**

1. G.J.L. Griffin, Chemistry and Technology of Biodegradable Polymers, Blackie Academic Professional, 1994.
2. Gerald Scott & Dan Gilad, Degradable Polymer – Principles & Applications, Chapman & Hall,
3. Y.DoI and K.Fukuda (Eds), Biodegradable Plastics and Polymers, Elsevier (1994)
4. Absorbabale & Biodegradable Polymers – S.N.Shalaby & K.J.L. Burg, CRC Press (2003).

## Elective - IV\_(Any One)

### CAD/CAM/CAE APPLICATION IN MOULD/TOOL

#### DESIGN (3-1-0)

1. Introduction – Basic Concepts of computer aided design – CAD and CADD system – shape and size description. Parametric programming – Construction of Engineering drawing – Two dimensional drafting – 3D surface and solid modeling – concepts of engineering data base-various techniques used to analyse the material properties.
2. Introduction to numerical control system – CNC machines – Types of control system for CNC machine – CNC processing – co-ordinate system – CNC axis and motion-CNC milling – CNC turning – CNC EDM – machining – CNC wire EDM concepts – concepts of CNC programme – tool motion – canned cycles – CNC interface with CAD-CNC stimulation software.
3. Computer integrated manufacturing (CIM) – computer aided design & manufacturing CAD/CAM process – advanced CAD/CAM Technology – Flexible Manufacturing System (FMS).  
Rapid prototyping – processor – Applications – Reverse Engineering - New generation cutting tools for mould manufacturing.
4. Computer Aided Engineering (CAE) – Finite Element Analysis (FEA) – Flow analysis – Thermal analysis – Warpage Analysis – Cooling Analysis – Shrinkage Analysis – Pressure Analysis – C Mould – Mould Flow Analysis – Introduction and Application.

#### Text Book:

1. Frank Nanfara, Tony Uccello, Derek Murphy, “The CNC Work Book” on Introduction to Computer Numerical Control, Addison, Wesley Publishing Company, USA, 1995.
2. Ibrahim Zeid, CAD/CAM – Theory & Practice, Mc. Graw Hill, International Edition, 1998.

#### MECHANICAL BEHAVIOUR OF POLYMERS (3-1-0)

1. Elastic, viscoelastic and flow behavior of polymers, theory of linear viscoelasticity.
2. Creep and stress relaxations in polymers, super position principle and time-temperature equivalence.
3. Stress – strain behavior of polymers and the dependence of stress – strain curve on internal and external factors, plastic behavior of polymers, concept of forced elasticity and zarkov relation, fatigue and life time of polymers, fracture of polymers.
4. Thermo mechanical behavior and analysis.

#### Text Books :

1. Compositional & Failure Analysis of Polymers John Scheoirs, John Willey & Sons Ltd.- 2000.
2. Mechanical Properties of Polymers & Composites by Nielson & Landel 2<sup>nd</sup> edition, Marcel Dekker Inc. 1994.

# PLASTICS WASTE MANAGEMENT AND RECYCLING (3-1-0)

1. Plastics Waste: Definition of plastics waste and the associated problems, Identification, collection methods and separation. Integrated waste management – source reduction, recycling, energy recovering process through thermal and biological destruction, Land filling and composting.
2. Recycling of plastics: Recycling and sustainability correlation, Basic principles and recovery, recycling and resource conservation. Recycling Technology.
3. Waste recycling and pollution control.
4. Environmental issues, policies and legislation in India.

## Text Book

1. R.J.Ehrig (Ed.), “Plastics Recycling – Products and Processes” Hanser Publication, Munich
2. Anthony L. Andrady (Ed.), “Plastics and the Environment”, Wiley Interscience, New York
3. Ministry Of Environments - Publications
4. R.J.Brandrup, “Recycling and recovery of Plastics”, Hanser Publications, Munich (1996).
5. N.Mustafa, “Plastics Waste Managements, Disposal Recycling and Reuse, marcel Dekker, New York (1993).

# POLYMER DEGRADATION AND STABILISATION (3-1-0)

## Unit I

Introduction and Thermal Degradation: Definition - Modes of Polymer Degradation -Mechanistic Aspects - Single Step Process and Chain Reactions - Auto Oxidation - Random and Specific Site Attack - Thermal Degradation: Introduction - Methods for Evaluation of Heat Resistance (DTA, DSC, TGA, TMA) - Mechanistic Aspects - Heat Resistance Polymers -Ablation –Stabilization – Thermal Degradation and Recycling – Heat Effect in Bio Polymers.

## Unit II

Mechanical Degradation and Ultrasonic Degradation: Introduction - Mechanistic Aspects - Degradation Studies - Polymer Degradation in Solution. Ultrasonic Degradation - Importance - Experimental Methods - Mechanism of Ultrasonic Degradation (Cavitations and Direct Effects) - Degradation Studies (Detection of Transient Species and Molecular Weight Distribution) Application of Mechanical Degradation: Stress - Induced Chemical Alterations of Polymers- Mastication of Natural and Synthetic Rubber - Mechano Chemical Synthesis of Block and Craft Copolymers.

## Unit III

Photo degradation: Introduction - Mechanistic Aspects (Excited States, Free Radicals and Ionic Species, Energy Transfer and Energy Migration) - Degradation in the Absence of Oxygen (Norrish Types I & II Reactions) - Photo Oxidation (Auto Oxidative Process, Sensitized Degradation) - Stabilization - Application: Polymers with Predictable Life Time, Photo resists.

## Unit IV

Degradation By High Energy Radiation and Biodegradation: Introduction - Aspects of Radiation - Mechanistic Aspects - Simultaneous Cross Linking and Degradation - Radiation Stability and Protection Radiation Effects in the Bio Polymers - Application: Lithography, X - Modes of Biological Degradation - Enzymatic Degradation in Bio Polymers (Polysaccharides, Proteins, Malice Acids) - Microbial Degradation of Synthetic Polymers -General Applications of Bio Degradable Plastics - Examples of Biodegradable Polyesters and Polyamides.

## Unit V

Chemical Degradation: Introduction - Solvolysis - Polymer Characterization by Solvolysis -Stability of Polymer Against Solvolytic Agents - Commercial Applications - Ozonisation -Oxidative Degradation - Auto Oxidation of Polymers. Ionic Degradation: Alkaline Degradation of Poly Saccharides Acidic Degradation of Polyaldehydes and Polyacetals and Cationic Degradation of Polypropylene Sulphide and Polyesters.

### Reference Books:

1. W. Schnabel, Polymer Degradation - Principles and Practical Applications Hanser Publishers, New York, 1992.
2. Ann - Christine Albertsson , Samuel J. Huang , "Degradative Polymers Recycling and Plastic Waste Management" Marcel Dekker, New York, 1995.
3. Reich; Leo and Stivala; Salvatores, Elements of Polymer Degradation, McGraw-Hill Book Co., New York (1971).
4. Scott; Gerald and Gilead; Dan (Eds.), Degradable Polymers: Principles and Applications, Chapman and Hall, London (1995).
5. Bastioli, Catia (Ed.), Handbook of Biodegradable Polymers, Rapra Technology Ltd., Shawbury (2006).

## Elctive –V (Any One)

### PRODUCTION MANAGEMENT (3-1-0)

#### Module – I (12 Hours)

1. Productivity : Importance, Productivity ratio, Productivity measurement, Productivity Index, awareness – Improvement – maintenance (A.I.M) process.
2. Production system : Models of production system, product Vs. Services, Process – focused & product focused systems, product strategies, product life cycle and production functions.
3. Forecasting : Methods – Moving average, exponential smoothing, regression analysis, coefficient of co-relation, Delphi, Market Survey.

#### Module – II (12 Hours)

4. Facilities Planning : Site location, facilities layout, workplace design, working conditions – noise, illumination.
5. Inventory Management EOQ models, safety stock and re-order level decisions, Distribution requirement planning, spare parts inventory control.

#### Module – III (10 Hours)

6. Motion study : Principles – economy, Time study – standard time.

#### Module – IV (12 Hours)

7. Production Planning & Control : aggregate planning, sequencing, Line balancing, Flow control, Dispatching, expediting, Gantt Chart, Line of balance, learning curve.

#### Text Books :

1. Riggs, J.L. Production Systems : Planning, Analysis & control John Wiley & Sons.
2. Buffa, E.S. & Sarin R.K.Modern Production / Operation Management, John Willey & Sons.
3. Chary, S.N. Production & Operations Management (TMH)
4. Muhelemann, Oakland & Lockyer, Production Operations Management, Macmillan.

# NYLON TECHNOLOGY (3-1-0)

## Unit I

History -Development and commercial Nylons Polyamidation-Principle of Polyamidation-Process Technologies-hydrolytic polymerisation-Ionic Polymerisation, Solid phase polymerisation and other polymerisation techniques. Chemistry-Polymerisation and equilibria, Kinetic molecular mass, deformation of chemical attack.

## Unit II

Physical structure: Structure properties relationship-crystallizing, melting temperature, to solubility, molecular weight, melt viscosity, degradation and stabilization, Electrical and mechanical properties. Characterisation: Identification, composition/moisture analysis, separation techniques, BGGmolecular mass and distribution, IR, NMR and X-ray diffraction.

## Unit III

Fundamentals of Melt Processing: Measurements of viscosity, PVT relationships, importance of moisture, effect of molecular mass, shear, temperature, additives and channel shape. Applications of Rheological data to flow situation.

Processing techniques of melt processing: Processing reagents, material handling and drying, injection moulding, extrusion, blow moulding and monomer processing. Other processing Techniques: Powder coating, blending and solution coatings. Secondary Treatments: Assembly, Moisture conditioning, mechanical surface clearing, and decorating.

## Unit IV

Modification: Physical change- co-polymerisation-transparent nylons, filled and reinforced nylons, toughened nylons, fire retardant nylons, plasticized and lubricated nylons, additives for heat stabilization, processing and color and other modifications.

Polymer Blends Alloys And Composites: Properties-factors affecting the properties of nylons, mechanical, thermal electrical and optical properties, moisture absorption, dimensional stability and density, environmental resistances and impact, flammability and failure analysis.

## Unit V

Commercial Nylon Blends And Their Applications: PA6, PA66, PA46, PA6/2, PA11 & PA12

Raw materials- preparation –polymerisation- Methods of manufacturing, modifications, processing (methods, procedure processing parameters etc.,)

Properties (material, tribological durability, water absorption dimension stability (immersion resistance, thermal/ electrical/optical properties, flammability resistance to permeation

Applications)

## Reference Books:

- iii) Malvin I. Kohan (ed.) Nylon plastics hand book, Hanser publisher, 1995.
- iv) Nicholar P. Chermisinof (ed.) Hand book of engineering Polymeric materials Marcel Dekker inc.N.Y. 19

# SPECIALITY ELASTOMERS (3-1-0)

## Unit I

Introduction of speciality Rubbers – Silicones (Q) – Introduction, Manufacture – Structure and its influence on properties – Compounding – Fabrication – Curing – General properties – Applications – Copolymers – PMQ, PVLQ, FMQ, FVMQ – Silicones Rubber for medical use.

## Unit II

Chlorosulphonated polyethylene – Introduction – Manufacture – Structure and its influence on properties – Compounding – Curing – Properties – Applications.

Epichlorohydrin – (CO, ECO, ETIR) – Introduction – Manufacture – Structure and its influence on properties – Compounding and Curing Properties and application.

Fluoro Elastomers (FKM) – Introduction – Manufacture – Structure and its influence on properties – Compounding – Curing – Properties and applications.

## Unit III

Polysulphides (TM) - Introduction, Manufacture – Cross linked Polyethylene (XLPE) – Polyurethane Rubbers – Introduction Manufacture – Structure and its influence on properties – Compounding – Curing – Properties and applications. Thermoplastic Polyurethanes – Introduction – Manufacture – Structure and its influence on Properties – Compounding – Curing – Properties and applications.

## Unit IV

Acrylic Rubber (ACM), Ethylene acrylic copolymers, Introduction, Manufacture – Structure and its influence on Properties – Compounding – Curing – Properties and applications. Ethylene Vinyl Acetate – Copolymer – Introduction, Manufacture – Structure and its influence on Properties – Compounding – Curing – Properties and applications

## Unit V

Chlorinated Polyethylene – Introduction – Manufacture – Structure and its influence on Properties – Compounding – Curing – Properties and applications. EPM, EDPM – Introduction, Manufacture – Structure and its influence on Properties – Compounding – Curing - Properties and applications.

## Reference Books:

1. Hoffmann, Rubber Technology Hand Book, Hanser Publishers Munich– 1989.
  2. Anil. K., Bhowmick, Howard L. Stephens (ed.) Hand Book of Elastomers, New
  3. Development & Technology, Marcel Decker Inc. New York, 1988
- Penn; W. S. (Ed.), Injection Moulding of Elastomers, MacLaren and Sons Ltd., London (1969).  
Houwink; R. (Ed.), Elastomers and Plastomers: Their Chemistry, Physics and Technology, Volume-1 General Theory, Elsevier Publishing Co., Inc., New York (1950).

# STRENGTH OF MATERIALS (3-1-0) 3 Cr.

## Unit – I

Elasticity: Stress and strain, compressive, tensile, shear and bearing stress - Stress - strain diagram, Hooks law, modulus of elasticity, modulus of rigidity, bulk modulus of rigidity, bulk modulus, Poisson's ration. Relationship between elastic constraints and temperature stresses, composite bars, dead, live and shock loads.

## Unit – II

Properties of section, calculation of areas, centroid, neutral axis, moment of inertia, modulus of section, radius of gyration with reference to structural shapes.

## Unit – III

Theory of simple bends - relationship between load shearing force and bending moment. Bending moment and shear force diagram for cantilever, simple supported and over hanging beams - bending stresses.

Deflection - deflection of beams in simple cases. Principal stresses and stains.

Torsion in solid and hollow shafts - combined bending and torsion.

## Unit – IV

Thin and thick cylinders and shells subjected to internal and external pressures.

## Unit – V

Column and struts - long and short columns - axial and eccentric loading - effect of end conditions – equivalent length and slenderness ratio - Euler and Rankine formulae.

Total Lectures = 45                  Tutorials = 15

### References Books:

1. R.S. Khurmi, Applied Mechanics and Strength of Materials S.Chand & Co., (6th ed), New Delhi,
2. P.N. Singh and I.K.Jha, Elementary Mechanics and Solids, Wiley Eastern, New Delhi.
3. Timoshenko, Strength of Materials
4. Singer, Strength of Materials

# SESSIONAL / LABORATORY

## **PLASTICS PROCESSING AND TESTING LAB – II (0-0-3)**

### **1. PLASTIC PROCESSING LAB (25 Hrs)**

1. Micro processor controlled Injection moulding machine operation.
2. Automatic Blow Moulding.
3. Vacuum Forming.
4. Rotational Moulding
5. Printing / Welding / Sealing of Plastics
6. FRP hand lay up process
7. Introduction to Mould & Machine Maintenance.

### **2. PLASTICS TESTING LABORATORY (20 Hrs)**

1.	Electrical Lab	:	Dielectric strength, Insulation resistance, (VR/SR), CTI, Arc resistance
2.	Thermal Lab	:	HDT/VSP, Thermal stability shrinkage, flammability – oxygen index.
3.	Optical Properties	:	Gloss, Haze, Clarity, Refractive index, light transmittance.
4.	Rheological Lab	:	Torque Rheometer, MFI, Capillary Rheometer
5.	Characterization Lab	:	DMA, FTIR, SEM, AAS
6.	Product Testing Lab	:	Testing as per National and International standards for various products such as pipes, films, fittings, tanks, cables, containers. Etc.

## **PLASTICS PRODUCT DESIGN & TOOLING – SOFTWARE Lab– II (0-0-3)**

1. Two plate mould design-multi impression
2. Three plate mould design (Injection – Multi impression)
3. Split Mould Design (injection)
4. Compression Mould Design
5. Transfer Mould Design
6. Mould Design for Industrial Components
7. Blow Mould Design
8. Extrusion Die Design.

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